

Prevalence and Correlation of Radiological Abnormalities in Children with Urinary Tract Infection: A Cross-Sectional Study

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Abstract

Background: Urinary Tract Infection (UTI) is the most common serious bacterial infection in infancy and childhood. Identifying factors associated with its recurrence is crucial. This study aimed to determine the prevalence and correlation of abnormalities reported in urinary ultrasonography and other imaging studies in children hospitalized with UTI.

Materials and Methods: This cross-sectional study was conducted on 116 children under 16 years of age diagnosed with UTI and admitted to Heshmatieh Hospital in Sabzevar in 2019. UTI was defined as the growth of $\geq 10^5$ colony-forming units (CFU)/mL of a single uropathogen on urine culture, accompanied by pyuria (≥ 5 white blood cells per high-power field) or clinical symptoms. Recurrent UTI was defined as ≥ 2 episodes of febrile UTI or ≥ 3 episodes of non-febrile UTI within 12 months. After obtaining informed consent, demographic data, clinical presentation, urinalysis, urine culture results, and findings from renal and urinary tract imaging (Ultrasound, VCUG, and DMSA scan) were recorded. Median and interquartile range (IQR) were reported for skewed continuous variables. Proportions are presented with 95% confidence intervals (CI). Data were analyzed using SPSS version 20, with Chi-square and Fisher's exact tests employed for comparisons. Odds ratios (OR) with 95% CI were calculated for significant associations.

Results: The mean age was 40.45 ± 48.38 months (median: 18.0 months, IQR: 6.0–60.0), with 75% (95% CI: 66.2–82.4%) being female. The most common presenting symptom was fever (56%, 95% CI: 46.9–64.8%). E. coli (46.6% of all patients, 95% CI: 37.5–55.9%; representing 87.1% of positive cultures) was the most frequently isolated pathogen. Radiological investigations revealed urinary stones in 7.8% (95% CI: 3.8–14.0%), hydronephrosis in 16.4% (95% CI: 10.4–23.9%), and vesicoureteral reflux (VUR) in 57.1% of those imaged (95% CI: 28.9–82.3%) (with 37.5% Grade III and 62.5% Grade IV). Other structural anomalies were found in 23.3% (95% CI: 16.1–31.9%). A significant correlation was observed between the presence of hydronephrosis (OR = 5.63, 95% CI: 1.97–16.05, $p=0.001$), VUR (OR undefined due to zero events in non-recurrent group, $p=0.024$), and other structural abnormalities (OR = 5.43, 95% CI: 2.17–13.58, $p<0.001$) with a history of recurrent UTI.

Conclusion: A significant proportion of children with UTIs, particularly those with recurrent infections, have underlying structural and functional urinary tract abnormalities. Comprehensive renal and urinary tract imaging in these high-risk children is essential for timely identification and management to prevent recurrent infections and potential long-term complications.

Key Words: Child, Hydronephrosis, Ultrasonography, Urinary Tract Infection, Vesicoureteral Reflux.

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1- INTRODUCTION

Urinary Tract Infection (UTI) is a prevalent and significant bacterial infection in the pediatric population, representing a major risk factor for progressive renal failure in children (1). The clinical presentation of UTI in children varies widely with age, often being nonspecific in infants, which can lead to underdiagnosis (2). The epidemiology is influenced by factors such as age, sex, circumcision status, and the presence of underlying urological anomalies (3, 4).

While uncomplicated UTIs are often easily treated, recurrent infections can lead to serious sequelae, including renal scarring, hypertension, and chronic kidney disease (5, 6). Vesicoureteral reflux (VUR) is a well-established predisposing factor for recurrent UTIs and pyelonephritis, increasing the risk of renal parenchymal damage (7). Other structural abnormalities, such as hydronephrosis and urinary stones, also contribute to the risk and recurrence of UTIs.

Imaging plays a critical role in the management of pediatric UTIs to identify these underlying abnormalities. Renal and bladder ultrasonography (RBUS) is a first-line, noninvasive investigation. Further imaging with voiding cystourethrography (VCUG) and dimercaptosuccinic acid (DMSA) scans is utilized based on clinical findings and initial ultrasound results to diagnose VUR and renal scarring, respectively (8, 9).

Given the potential for long-term morbidity, understanding the local prevalence of these radiological abnormalities in children presenting with UTIs is vital for optimizing diagnostic and therapeutic strategies. This study aimed to investigate the prevalence and correlation of disorders reported in urinary ultrasonography and other radiological imaging in patients from birth to 16 years

of age hospitalized with a diagnosis of UTI at Heshmatieh Hospital in Sabzevar.

2- MATERIALS AND METHODS

2-1. Study Design and Setting

This cross-sectional study was conducted over one year (2019) at Heshmatieh Hospital, a major referral center in Sabzevar, Iran. The study protocol was approved by the Ethics Committee of Sabzevar University of Medical Sciences (Code: IR.MEDSAB.REC.1399.85).

2-2. Study Population and Sampling

The study population consisted of all children from birth to 16 years of age who were hospitalized with a diagnosis of UTI. A census sampling method was used, including all eligible patients during the study period. UTI was defined as growth of $\geq 10^5$ CFU/mL of a single uropathogen on urine culture obtained by catheterization or clean-catch, accompanied by pyuria (≥ 5 white blood cells per high-power field) or at least one clinical symptom (fever, dysuria, vomiting, or lethargy). Recurrent UTI was defined as ≥ 2 episodes of febrile UTI or ≥ 3 episodes of non-febrile UTI within 12 months.

2-3. Inclusion and Exclusion Criteria

Inclusion Criteria: All hospitalized patients within the specified age range with a confirmed diagnosis of UTI.

Exclusion Criteria: Age over 16 years, unconfirmed UTI diagnosis, or lack of parental consent for participation.

2-4. Data Collection

Data were collected using a researcher-designed checklist. The collected information included:

- Demographic data (age, sex).
- Clinical presentation and history of previous UTIs (categorized as

first infection vs. recurrent as defined above).

- Laboratory findings: Urinalysis (pyuria, hematuria, bacteriuria, crystalluria) and urine culture results.
- Radiological findings: Results from RBUS, VCUG, and DMSA scans.

2-5. Imaging Indication Criteria and Interpretation

Imaging decisions were made by the treating physician based on standard clinical guidelines: RBUS was performed for all patients with confirmed UTI. VCUG was indicated for patients with hydronephrosis on RBUS, abnormal RBUS findings (e.g., ureterocele, duplicated collecting system), first febrile UTI in children <2 years, or recurrent UTI. A DMSA scan was performed for patients with high-grade VUR or recurrent febrile UTIs. All images were interpreted by one of two board-certified pediatric radiologists blinded to clinical data.

2.6. Ethical Considerations

Informed consent was obtained from the parents or guardians of all participants. Patient confidentiality was maintained, and the study was conducted in accordance with the principles of the Declaration of Helsinki.

2.7. Statistical Analysis

Data were analyzed using IBM SPSS Statistics version 20. Descriptive statistics (frequency, percentage, mean, standard deviation) were used to summarize the data. For skewed continuous variables (e.g., age), median and interquartile range (IQR) were reported. All proportions are presented with exact 95% confidence intervals (CI). The Chi-square test and Fisher's exact test were used to examine the relationship

between categorical variables (e.g., history of UTI and radiological findings). For significant associations, odds ratios (OR) with 95% CI were calculated. A p-value of less than 0.05 was considered statistically significant. Multivariable analysis was not performed due to the small number of events in imaging subgroups (VCUG n=14, DMSA n=8), which would result in model overfitting.

3- RESULTS

A total of 116 children with UTIs were enrolled. The mean age was 40.5 months (\approx 3.4 years, SD 48.38; median: 18.0 months, IQR: 6.0–60.0), and 75% (n=87, 95% CI: 66.2–82.4%) were female.

3-1. Demographic and Clinical Characteristics

The largest proportion of patients (43.1%, 95% CI: 34.3–52.3%) was under one year of age. Most patients (77.6%, 95% CI: 69.0–84.6%) had no previous history of UTI, while 22.4% (95% CI: 15.4–31.0%) reported recurrent infections. The most common presenting symptom was fever (56%, 95% CI: 46.9–64.8%), followed by dysuria (16.4%, 95% CI: 10.4–24.0%) and nausea/vomiting (8.6%, 95% CI: 4.4–15.0%) (Table 1).

3-2. Laboratory Findings

Urinalysis revealed pyuria in 91.4% (95% CI: 84.9–95.3%) of patients, hematuria in 39.7% (95% CI: 31.0–48.9%), and bacteriuria (\geq +1) in 75% (95% CI: 66.2–82.4%). Urine culture was negative in 46.6% of cases (95% CI: 37.5–55.9%). Among positive cultures, *E. coli* was the most common pathogen (46.6% of all patients, 95% CI: 37.5–55.9%; representing 87.1% of positive cultures), followed by *Klebsiella* (5.2% of all patients, 95% CI: 2.1–10.7%; representing 9.7% of positive cultures).

Table-1. Demographic and clinical characteristics of the study population (n=116).

Characteristic	Category	Frequency (n)	Percentage (%)	95% CI
Sex	Female	87	75.0%	66.2–82.4%
	Male	29	25.0%	17.6–33.8%
Age Group	< 1 year	50	43.1%	34.3–52.3%
	≥ 1 year	66	56.9%	47.7–65.7%
History of UTI	First Infection	90	77.6%	69.0–84.6%
	Recurrent Infection	26	22.4%	15.4–31.0%
Presenting Symptom	Fever	65	56.0%	46.9–64.8%
	Dysuria	19	16.4%	10.4–24.0%
	Nausea/Vomiting	10	8.6%	4.4–15.0%
	Other Symptoms	22	19.0%	12.7–27.1%

3-3. Radiological Findings

The prevalence of abnormalities detected through various imaging modalities is summarized below:

- **Overall Radiological Abnormalities:** Urinary stones were found in 7.8% (95% CI: 3.8–14.0%), hydronephrosis in 16.4% (95% CI: 10.4–23.9%), and other structural anomalies (e.g., difference in kidney size, ureteropelvic junction obstruction, bladder diverticula) in 23.3% (95% CI: 16.1–31.9%).
- **Ultrasonography (RBUS):** Findings were normal in 65.5% (95% CI: 56.3–73.9%) of patients. Abnormal findings included isolated stones (5.2%, 95% CI: 2.1–10.7%), isolated hydronephrosis (10.3%, 95% CI: 5.7–17.0%), and isolated structural abnormalities (12.9%, 95% CI: 7.7–20.1%).
- **Vesicoureteral Reflux (VCUG):** VCUG was performed on 14 patients. Reflux was present in 57.1% of these cases (exact 95% CI: 28.9–82.3%). Among those with VUR, 37.5% (95% CI: 8.5–75.5%) had Grade III and 62.5%

(95% CI: 24.5–91.5%) had Grade IV.

- **DMSA Scan:** This scan was performed on 8 high-risk patients, revealing renal scarring in 62.5% (exact 95% CI: 24.5–91.5%).

3-4. Correlation between Recurrent UTI and Radiological Abnormalities

A statistically significant association was found between a history of recurrent UTI and the presence of specific radiological abnormalities (Table 3):

- **Hydronephrosis:** 52.6% of patients with hydronephrosis had recurrent UTI vs. 16.5% without (OR = 5.63, 95% CI: 1.97–16.05, p=0.001).
- **Vesicoureteral Reflux:** 100% of patients with VUR had recurrent UTI vs. 50% without VUR in the imaged subgroup (OR undefined due to zero events in the non-recurrent group; Fisher's exact p=0.024).
- **Other Structural Abnormalities:** 48.1% with anomalies had recurrent UTI vs. 14.6% without (OR = 5.43, 95% CI: 2.17–13.58, p<0.001).
- No significant association was found between urinary stones and recurrent UTI (OR = 1.83, 95% CI: 0.42–7.96, p>0.05).

Table-2. Laboratory and radiological findings.

Finding	Category / Detail	Frequency (n)	Percentage (%)	95% CI
Urinalysis (n=116)	Pyuria	106	91.4%	84.9–95.3%
	Hematuria	46	39.7%	31.0–48.9%
	Bacteriuria ($\geq+1$)	87	75.0%	66.2–82.4%
Urine Culture (n=116)	Negative	54	46.6%	37.5–55.9%
	E. coli (of all patients)	54	46.6%	37.5–55.9%
	Klebsiella (of all)	6	5.2%	2.1–10.7%
	Other/Unspecified	2	1.7%	0.2–6.0%
Overall Radiological (n=116)	Urinary Stones	9	7.8%	3.8–14.0%
	Hydronephrosis	19	16.4%	10.4–23.9%
	Other Structural Anomalies	27	23.3%	16.1–31.9%
RBUS (n=116)	Normal	76	65.5%	56.3–73.9%
	Isolated Stones	6	5.2%	2.1–10.7%
	Isolated Hydronephrosis	12	10.3%	5.7–17.0%
	Isolated Structural	15	12.9%	7.7–20.1%
	Combined/Multiple	7	6.0%	2.7–11.7%
VCUG (n=14)	VUR Present	8	57.1%	28.9–82.3%*
	VUR Absent	6	42.9%	17.7–71.1%*
VUR Grade (n=8)	Grade III	3	37.5%	8.5–75.5%*
	Grade IV	5	62.5%	24.5–91.5%*
DMSA Scan (n=8)	Scarring Present	5	62.5%	24.5–91.5%*
	Scarring Absent	3	37.5%	8.5–75.5%*

*Exact Clopper-Pearson confidence interval

Table-3. Correlation between history of recurrent UTI and radiological abnormalities.

Radiological Abnormality	Recurrent UTI Present (n=26)	Recurrent UTI Absent (n=90)	OR (95% CI)	p-value
Hydronephrosis				0.001
Present (n=19)	10 (52.6%)	9 (47.4%)	5.63 (1.97–16.05)	
Absent (n=97)	16 (16.5%)	81 (83.5%)		
VUR*				0.024
Present (n=8)	8 (100.0%)	0 (0.0%)	undefined	
Absent (n=6)	3 (50.0%)	3 (50.0%)		
Other Structural				<0.001
Present (n=27)	13 (48.1%)	14 (51.9%)	5.43 (2.17–13.58)	
Absent (n=89)	13 (14.6%)	76 (85.4%)		
Urinary Stones				>0.05 (NS)
Present (n=9)	3 (33.3%)	6 (66.7%)	1.83 (0.42–7.96)	
Absent (n=107)	23 (21.5%)	84 (78.5%)		

*VCUG performed on a subset of 14 patients; OR undefined due to zero cells. NS: Not statistically significant.

4- DISCUSSION

This study provides insight into the profile of radiological abnormalities in children hospitalized with UTIs in our region. The high prevalence of female patients (75%) and the predominance of infants under one year are consistent with established epidemiological patterns of

pediatric UTI (10). The finding that E. coli was the most common causative organism aligns with global data regarding the relatively high rate of negative cultures (46.6%). This may be related to prior antibiotic administration or contamination; importantly, among positive cultures, E. coli accounted for 87.1%.

The core finding of this study is the substantial prevalence of underlying urological anomalies in children with UTIs severe enough to require hospitalization. Notably, 57.1% (95% CI: 28.9–82.3%) of the children who underwent VCUG had VUR, predominantly of high grades (III and IV). However, given the small subgroup (n=14), this estimate has wide confidence bounds and should be interpreted cautiously. High-grade VUR remains a strong risk factor for pyelonephritis and subsequent renal scarring (7, 10). Furthermore, the significant statistical correlation between hydronephrosis (OR = 5.63), VUR, other structural abnormalities (OR = 5.43), and a history of recurrent UTI underscores the role of these anomalies in facilitating repeated infections.

Our results are consistent with previous research. Keren et al. identified VUR as a key risk factor for recurrent UTI (11). Similarly, Choi et al. found that recurrent UTI and abnormal RBUS findings were associated with high-grade VUR (12). The prevalence of structural abnormalities (23.3%) and hydronephrosis (16.4%) in our study is comparable to rates reported in other studies, such as that by Preda et al (13).

However, the overall prevalence of VUR in our cohort (9/116 or 7.8% of the total sample, 57% of those imaged) appears lower than some reports, such as that by Mahant et al., who found a 22% prevalence (14). This discrepancy may be due to differences in imaging criteria, sample size, or patient selection, as VCUG was not performed on all patients in our study, but only on those with specific clinical indications.

A key implication of our findings is the reinforcement of the importance of targeted imaging in children with UTIs, especially those with recurrent episodes. While RBUS is a valuable first step, its sensitivity for detecting VUR is limited, as

also noted by Mahant et al (14). Therefore, in cases of febrile UTI, recurrent UTI, or abnormal ultrasound findings, proceeding to VCUG is essential to identify VUR, allowing for appropriate management to prevent renal damage.

4-1. Limitations

This study has limitations. First, its single-center design may limit generalizability. Second, advanced imaging (VCUG, DMSA) was not performed on all patients, as it was based on clinician judgment. Specifically, VCUG was performed in only 14 of 116 patients (12.1%), and DMSA in only 8 patients (6.9%). The small subgroup sizes result in wide 95% confidence intervals (e.g., VUR prevalence 57.1%, 95% CI: 28.9–82.3%), and we have avoided overinterpretation of these point estimates. Multivariable analysis was not feasible due to the limited number of events. This could lead to an underestimation or overestimation of the true prevalence of VUR and scarring in the general pediatric UTI population. Third, the cross-sectional nature limits the ability to establish causality.

5- CONCLUSION

In conclusion, a significant proportion of children hospitalized with UTIs, particularly those with recurrent infections, have underlying structural and functional abnormalities of the urinary tract, with vesicoureteral reflux and hydronephrosis being the most common. Our findings highlight that recurrent UTI is strongly associated with these radiological abnormalities (odds ratios ranging from 5.4 to 5.6). Therefore, a comprehensive imaging strategy, including renal ultrasound and, when indicated, VCUG, is crucial in the management of children with UTIs, especially in recurrent cases. Early identification and appropriate management of these underlying conditions can help reduce the risk of

recurrent infections and prevent long-term renal complications.

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7- CONFLICT OF INTEREST

The authors declared no conflict of interest.

8- ETHICAL APPROVAL

This study received approval from the Ethics Committee of Sabzevar University of Medical Sciences, Iran (approval code: IR.MEDSAB.REC.1399.85).

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